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Project No. P0111-02

Mr. John J. Hunter
Corporate Manager of Process Engineering
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Number Ten, Tantalum Place
Muskogee, OK 74401

Work Plan for Engineering and Geological Investigations
Closure of Impoundments 6, 7, 8, and 9

Dear Mr. Hunter:

Per your request and in accordance with our October 7, 1991 meeting with the Oklahoma Water Resources Board (OWRB), Earth Sciences Consultants, Inc. (Earth Sciences) is presenting this work plan to perform engineering and geological investigations of Impoundments 6, 7, 8, and 9 at Fansteel Metals' (Fansteel) Muskogee, Oklahoma facility. The purposes of this project are to perform necessary geological and engineering investigations to obtain the required data to develop closure plans for the impoundments and to ensure that the closure will be accepted and approved by the OWRB. This work plan has been prepared based on a visit to the site, our previous experience at the facility, and meetings on October 7 and 8, 1991 to discuss the closure of the impoundments.

The scope of work presented in the following sections will be performed in accordance with the specifications set forth in the February 1991 Remedial Assessment (RA) work plan for the Fansteel facility. Additional work activities are presented beyond those of the RA work plan to ensure a comprehensive assessment of the Ponds Nos. 6, 7, 8, and 9 areas prior to closure. The scope of work to be performed during the investigation includes a background radiation survey, installation of groundwater monitoring wells and an evaluation of the hydrogeology of the site, determination of the amount and characteristics of materials contained within the impoundments, an investigation into the impacts that the impoundments have had (if any) on surface water, slope stability analysis on the earthen embankments of the existing impoundments, solidification and stabilization studies and engineering of the various closure elements, and preparation of a limited risk assessment of the potential environmental impacts. Each of these items is discussed in greater detail in the remainder of this plan.

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Work Scope

The work elements described within this section will provide sufficient data to enable the design of closure methods for the four impoundments. Each of these work elements is described in the following paragraphs.

Site Background Radiological Survey

Initially, a site-wide grid will be established by survey and marked in the field. The grid will employ 10-meter spacing within the confines of the identified study areas (I through V) and 25-meter spacing outside the study area boundaries shown in Figure 12. Grid intersections will be marked in the field using pin flags, stakes, marking paint, or other effective means depending upon field conditions. Off-site background measurement locations will be field located using topographic maps and durable landmarks.

Ambient radioactivity will be measured using a Ludlum Model 44-10 gamma scintillation detector and a Ludlum Model 44-7 or 44-21 beta/gamma detector sensitive to beta and gamma radiation. Each grid intersection will be measured at two locations. The Ludlum Model 44-10 scintillation detector will be used to obtain a measurement within 1 centimeter of the ground surface and a second measurement at a height of 1 meter above the ground surface. A Ludlum Model 44-7 or 44-21 beta/gamma detector will also be used to obtain a radiation measurement at each grid intersection within 1 centimeter of the ground surface.

The background radiochemical characteristics of the general area will be determined by a program of off-site sampling and instrumental measurements. Several external factors contribute complications to the choice of sampling and measurement locations. The first of these factors is the presence of the Arkansas River. In the case of a mature river such as this one, one bank will typically be characterized by net erosion and loss of material downstream; the other bank by deposition and net gain of material from upstream. While these processes are inherently dynamic, they may be considered static for purposes of determination of the radiological impact of the Fansteel facility over its operational life. In order to retain comparability, all background samples and measurements will be obtained from the same side of the river as the Fansteel operation.

Other complicating factors include the extent of industrial development in the immediate surroundings. This development, including the presence of a large electrical generating plant as well as other manufacturing and transportation facilities, may have resulted in the placement of dredged fill and other exogenous material on the land surface and the deposition of contaminants including possible trace amounts of radioactive materials. Background sample locations will be chosen with a deliberate attempt to avoid distinct areas of fill material or areas visibly affected by other industrial activity.

Within these constraints, a minimum of ten off-site sample locations will be chosen to determine background radioactivity conditions. Each background location will be measured for gamma radiation field strength within 1 centimeter of the surface and at a height of 1 meter above the ground surface. Beta/gamma

measurements will also be obtained from each location within 1 centimeter of the ground surface.

A surface soil sample will be obtained at each off-site background location. These samples will be representative of the top 6 inches of earth materials. Each sample will be analyzed for gross alpha, gross beta, uranium (isotopes 234 and 238), thorium (isotopes 228 and 232), and radium (isotopes 226 and 228). These samples will be considered representative of the radiological background conditions for purposes of comparing conditions found on the Fansteel site.

After the instrument survey of the site has been completed, the data will be examined to determine if the predetermined operational boundaries of the study areas are appropriate for decommissioning purposes. Additional instrument readings may be obtained to further delineate areas exhibiting elevated radiation responses. The area determined to lie outside the study areas will then be sampled to determine background gross alpha and beta activity in site soil. Soil samples will be collected from a depth of 6 inches below ground surface from at least 20 randomly selected grid intersections. A random number generation technique will be used to select sample sites for this operation.

These surface soil samples will be submitted for laboratory determination of gross alpha and beta activity. Analytical results will be examined for statistical consistency and conformance with the off-site background mean value for gross activity. Any samples that show significantly higher activity than the calculated mean of the off-site background samples will be further analyzed to determine the specific isotopes responsible for the observed elevated activity. The single tailed value of Student's "t" at the 90 percent confidence level will be used as the test for significance. This is a generous estimator of significance so it will not be used to test for outliers. Outliers will be tested by Dixon's method at the 95 percent confidence level. In the event any outliers are identified, the grid point supplying the outlier will be resampled to confirm the presence or absence of elevated radioactivity.

In addition to determining the approximate boundary of the region outside the study areas at the site, the information developed during this survey will be used to identify the location of further sampling operations in order to define the extent and location of areas of radioactive contamination and to aid in developing proper closure plans for Ponds Nos. 6, 7, 8, and 9.

Hydrogeologic Impacts

To investigate the potential hydrogeologic impacts of the in-place closure of Impoundments 8 and 9 and the clean closure of Impoundments 6 and 7, Earth Sciences recommends the following activities be conducted in accordance with the OWRB draft rules dated October 3, 1991:

- Four groundwater monitoring wells will be installed adjacent to Impoundments 8 and 9. These wells will communicate with the first water-bearing zone. They will be advanced to the base of the first aquifer or to a depth of 100 feet, whichever is encountered

first. The boreholes will be advanced using hollow-stem augers with soil samples being collected at 5-foot centers using a split-spoon sampler. The split-spoon sampler will be advanced utilizing standard penetration test techniques. Undisturbed samples will be obtained by collecting two Shelby tubes from each boring, one above the water table and one below, to establish geotechnical and hydraulic properties of the soil materials. Additionally, two soil samples will be collected from each boring and analyzed for total metals (tantalum, columbium, tin, lead, nickel, antimony, arsenic, barium, cadmium, calcium, chromium, mercury, selenium, and silver), total fluoride, total ammonia, total sulfate, nitrate, methyl isobutyl ketone (MIBK), gross alpha, gross beta, and isotopic analyses of constituents. Table 1 summarizes the sample locations and respective analytical parameters. One sample from each boring will be collected immediately above the water table. The second sample to be analyzed will be selected based on the highest vapor reading detected while scanning soil samples with an organic vapor analyzer. Earth Sciences will provide supervision of drilling and monitoring well installation.

- The new monitoring wells will be surveyed to the site grid system to obtain their elevations and locations. This task will be completed utilizing the licensed surveyor familiar with on-site controls.

- Groundwater samples will be collected from all five monitoring wells which are adjacent to the surface impoundments. Earth Sciences will provide on-site supervision of sample collection.

- Groundwater samples will be analyzed for total metals (tantalum, columbium, tin, lead, nickel, antimony, arsenic, barium, cadmium, calcium, chromium, mercury, selenium, and silver), sulfate, fluoride, ammonia, MIBK, gross alpha, gross beta, and isotopic analyses of constituents (Table 1). Groundwater analyses for all parameters except the radiological analysis will be conducted by Antech Ltd. (Antech), Earth Sciences' affiliated laboratory. All radiological analyses will be performed by Golden, Colorado as previously identified by Fansteel as their radiological laboratory.

- Aquifer characterization (slug) tests will be performed in three of the wells adjacent to the surface impoundments. These slug tests will provide data to

enable the calculation of various hydrogeologic parameters such as hydraulic conductivity and groundwater flow velocity. Earth Sciences will provide on-site personnel and appropriate equipment to conduct the tests and analyze the data.

Surface Water Impacts

Earth Sciences recommends that the potential impact of surface water be investigated by sampling sediments from two locations along the riverbank near the waterline in the vicinity of the ponds in question. These sediments should be analyzed for the same suite of parameters indicated for the groundwater samples.

For long-term monitoring in accordance with OWRB draft rules for closures, we recommend that two surface water samples be collected on a regular basis (quarterly); one upstream and one downstream of the impoundments. The first set of samples will be collected during this investigation from the two locations. These surface water samples will be similarly analyzed for the parameter suite identified for the groundwater samples.

Characterization of Materials Within Impoundments 6, 7, 8, and 9

The materials contained within wastewater treatment Impoundments 6, 7, 8, and 9 will be characterized to aid in evaluating appropriate closure alternatives. A minimum of 12 sampling locations (one in Impoundment 6, one in Impoundment 7, five in Impoundment 8, and five in Impoundment 9) has been selected in these impoundments as detailed in the RA work plan (Figure 12). Depending on the horizontal distribution and consistency of materials identified at each sampling point within Impoundments 8 and 9, additional sampling locations may be required to more comprehensively characterize the nature of materials within these impoundments. Sampling and materials characterization will be performed in accordance with the following work scope.

A Coliwasa sampling device, or similar sampling equipment, will be used to obtain representative vertical individual depth impoundment residue samples. Three vertical composite samples will be collected at each sampling point within the four impoundments. Vertical residue samples collected from the sampling points located in each impoundment will be collected at the following depth intervals: Impoundment 6 - 0 to 3 feet, 3 to 6 feet, and 6 to 9 feet; Impoundment 7 - 0 to 2.5 feet, 2.5 to 5 feet, and 5 to 7 feet; Impoundment 8 - 0 to 8 feet, 8 to 16 feet, and 16 to 24 feet; and Impoundment 9 - 0 to 7 feet, 7 to 14 feet, and 14 to 20 feet. A total of 36 vertical composite samples will be collected. If sample acquisition is not possible with the Coliwasa sampler, a drill rig will be required to obtain waste samples.

These samples will be screened with an H-Nu meter to determine whether volatile organic compounds may be present and with a Bicron μR meter, or instrument of similar capability, and a thin window Geiger-Mueller beta/gamma meter for the presence of radionuclides. Samples will be split for chemical characterization and for geotechnical analysis. Each of the 36 vertical composite samples will

be submitted to Antech for the analysis or coordination of analysis for the following parameters: total fluoride, total ammonia, total sulfate, gross alpha, gross beta, isotopic analyses of constituents, MIBK, and total metals (tantalum, columbium, tin, lead, nickel, antimony, arsenic, barium, cadmium, calcium, chromium, mercury, selenium, and silver). Additionally, Toxicity Characteristic Leaching Procedure (TCLP) analyses will be performed on three samples exhibiting the highest total metal content each from Impoundments 8 and 9 and one sample each from Impoundments 6 and 7. TCLP organic analysis will be performed on two samples each from Impoundments 8 and 9 and one sample each from Impoundments 6 and 7. The other set of samples will be submitted for geotechnical analysis as described below in Solidification and Stabilization. All sampling and analytical procedures will be performed in accordance with the requirements specified in the RA work plan (February 1991) prepared by Earth Sciences. Table 1 summarizes the sample locations and respective analytical parameters.

Slope Stability Analysis

A slope stability analysis will be performed on the critical embankment sections for all four impoundments. The purpose of the analysis is to determine the long-term steady-state condition of each embankment. The slope stability analysis will be performed using the existing embankment configurations as depicted on site topographic maps. A minimum of one test boring will be required on each embankment of Ponds Nos. 8 and 9 (eight borings total) for geotechnical analysis of existing embankment conditions for input into the slope stability analysis. Standard engineering slope stability computer programs will be used for the analysis. Analyses will be performed under static and dynamic conditions to determine safety factors of the embankments under varying geotechnical conditions. Analytical results will be depicted on drawings of critical embankment cross sections. A summary table containing analytical parameters and results will be included on each drawing. Results of the analysis will also be described in a narrative enclosed with the closure documents.

Solidification and Stabilization

Investigations will be performed to determine the most suitable and cost-effective method of stabilizing the wastes in Impoundments 8 and 9. Solidification testing will involve samples of waste from Impoundments 8 and 9 collected during the characterization work, mixing the samples with various quantities of fly ash, and performing shear strength analyses on the samples. Results will be used to design the method of solidifying and stabilizing the wastes in the impoundments. Geotechnical characterization of untreated wastes will also be required for evaluation and analysis of the solidification stabilization process.

Earth Sciences will provide technical assistance to direct Fansteel personnel during the sample procurement, sample preparation, and delivery of samples to a soils testing laboratory. Sample procurement will consist of obtaining samples of sludge from five test borings in Impoundment 8, five in Impoundment 9, one test boring in Impoundment 6, and one in Impoundment 7. Three composite samples will be obtained from each test boring. Samples will be prepared by mixing various amounts of fly ash to the waste samples. The prepared samples will be delivered to a soils testing laboratory for shear strength analysis. Untreated

samples of waste will also be delivered to the laboratory to obtain basic geotechnical properties. Included in the laboratory analysis will be grain-size distribution, Atterberg limits, unit weight, moisture content, shear strength, and consolidation.

Engineering

The engineering phase of this project will consist of an evaluation and analysis of the solidification/stabilization process, a design of the cap and final cover system for the impoundments, an embankment design for the impoundments (should slope stability analysis indicate a need), and preparation of specifications and bid documents for closure activities. The evaluation and analysis will be performed to determine the depth and method of solidification/stabilization required and the load-bearing capacity of the underlying sludges which will not be stabilized. The final cover system design will be performed to determine the most cost-effective means of constructing the cap, drainage system, and final cover (including revegetation). Should the slope stability analysis indicate a need, it may be necessary to redesign all or parts of the impoundments' outslopes to ensure long-term stability. This work, if needed, will be performed during this phase of the investigation.

Upon approval of the closure process by Fansteel and the OWRB, job specifications and bid documents will be prepared. Technical aspects to be included in the job specifications and bid documents will be the pond closure methodologies and staging requirements, equipment requirements, waste-to-fly-ash mixture ratios, quantities of materials required, and final cover system construction requirements (including quantities of material, placement, and construction of the final cover system). Job specifications and bid documents will be prepared in a format ready for contractors to solicit bids.

Limited Risk Assessment

Earth Sciences will conduct a detailed evaluation of the data obtained during this investigation as well as publicly available geologic and hydrogeologic information to identify potential risks to human health or the environment associated with the subject site. This evaluation will focus on site-related risks to groundwater, surface water, and soil. No evaluation of other media will be considered at this time. Accordingly, groundwater and surface water transport and potential exposures related to groundwater will be quantitatively evaluated.

A preliminary fate and transport evaluation will be conducted to estimate migration pathways associated with the area. Potential contaminant transport media (surface water and groundwater flow) will be evaluated to establish the primary available migration pathway. Preliminary flow modeling will be conducted utilizing values for various hydrogeologic parameters obtained from the slug tests to establish a preliminary estimate of potential contaminant flow through the environmental system.

Quantification of potential site-related risks will be based on a mechanistic approach using current guidance and reference documents. Risk estimates will be developed in accordance with accepted procedures for evaluation of potential

health and environmental risks using the most recent guidance available from U.S. Environmental Protection Agency (USEPA). The primary guidelines and protocols for performance of the risk evaluation will be derived from Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (EPA/546/1-89/002); Exposure Factors Handbook (EPA/600/8-89/040); and Risk Assessment Guidance for Superfund Volume II, Environmental Evaluation Manual (EPA/540/1-89/001). Assessment of potential human health risks will be based on USEPA-approved reference doses and/or carcinogenic slope factors. The risk assessment will consider current baseline risks as well as potential site-related risks 5 to 10 years in the future. The risk assessment will be prepared utilizing existing information and estimations of various hydrogeologic parameters.

Final Report

Following the completion of all field and analytical work, Earth Sciences will prepare a final report which includes a discussion of all field activities, presentation of analytical and geotechnical data, an evaluation of the hydrogeologic regime in the vicinity of the impoundments, a characterization of impoundment residues, results of the slope stability analyses and solidification/stabilization investigations, and a discussion and evaluation of the limited risk assessment. An integral part of this document will be an engineering report for closure of Impoundments 6, 7, 8, and 9.

Schedule

Earth Sciences estimates that field activities associated with this work plan will require approximately 18 working days to complete. Laboratory analyses will be completed within 3 to 4 weeks of the completion of all fieldwork. The final report will be submitted within 4 to 6 weeks of Earth Sciences receipt of all analytical data.

Earth Sciences appreciates this opportunity to continue to provide Fansteel with our environmental services and we look forward to working with you on this project. If you have any questions regarding this work plan, please contact us.

Respectfully submitted,

Joseph M. Harrick
Project Manager

Gary W. Berman, P.E.
Executive Vice President

JMH/GWB:vlv

Enclosure

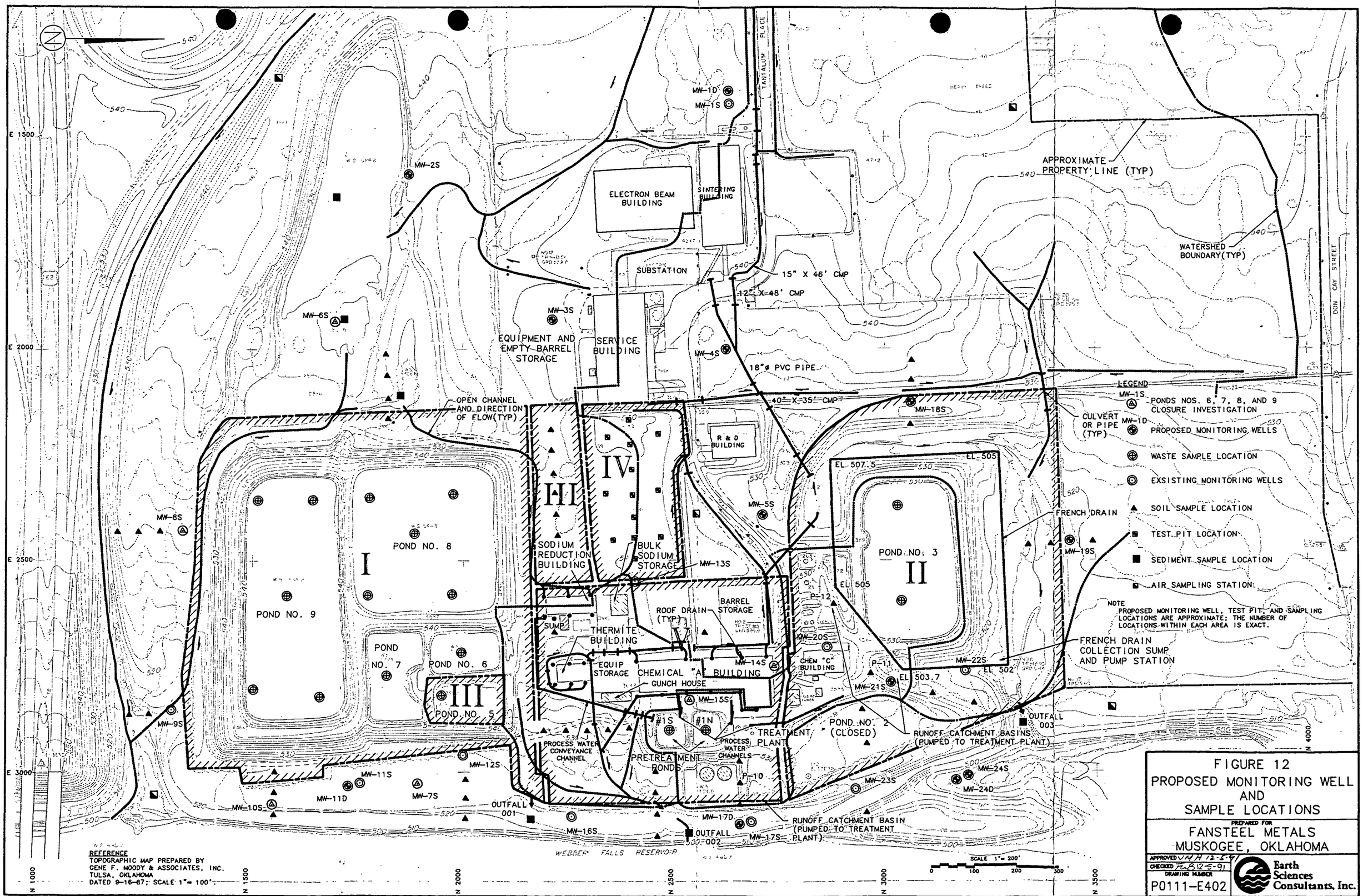
Table

Table 1
Proposed Sampling Program
Fansteel Metals Facility
Muskogee, Oklahoma

Hydrogeologic Impact Study	Analytical Program
Soil Sampling MW-6S, MW-7S, MW-8S, MW-10S (8 Samples)	Total metals, fluoride, ammonia, nitrate, MIBK, gross alpha, gross beta, uranium, thorium, isotopic analysis of uranium, and thorium daughter products
Groundwater Sampling New Installations: MW-6S, MW-7S, MW-8S, MW-10S Existing Installations: MW-9S, MW-11S, MW-12S, MW-16S, MW-13S (9 samples)	Total metals, fluoride, ammonia, nitrate, MIBK, gross alpha, gross beta, uranium, thorium, isotopic analysis of uranium, and thorium daughter products
Surface Water Sampling (2 samples)	Total metals, fluoride, ammonia, nitrate, MIBK, gross alpha, gross beta, uranium, thorium, isotopic analysis of uranium, and thorium daughter
Waste Characterization Study	
Impoundment No. 6 (3 samples) Impoundment No. 7 (3 samples) Impoundment No. 8 (15 samples) Impoundment No. 9 (15 samples)	Total metals, fluoride, ammonia, nitrate, MIBK, gross alpha, gross beta, uranium, thorium, isotopic analysis of uranium, and thorium daughter products
Impoundment No. 6 (1 sample)(1) Impoundment No. 7 (1 sample)(1) Impoundment No. 8 (3 samples)(1) Impoundment No. 9 (3 samples)(1)	TCLP organic analysis

(1)Samples exhibiting highest total metal content from original sample set will be selected for TCLP analysis.

Figure



REFERENCE
TOPOGRAPHIC MAP PREPARED BY
GENE F. MOODY & ASSOCIATES, INC.
TULSA, OKLAHOMA
DATED 9-16-87; SCALE 1"= 100'.

FIGURE 12
PROPOSED MONITORING WELL AND SAMPLE LOCATIONS

PREPARED FOR
FANSTEEL METALS
MUSKOGEE, OKLAHOMA

APPROVED JAH 12-5-91
CHECKED FeB 12-5-91
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